NASA TECH BRIEF

Metal Cooldown, Flow Instability, and Heat Transfer in Two-phase Hydrogen Flow

An experimental investigation was conducted on the cooldown of coated and uncoated metal tubes, and of flow instability and heat transfer in two-phase hydrogen flow. The cooldown experiments were conducted at relatively low pressures (50 to 100 psia); the instability investigation concentrated in the region of the critical pressure of hydrogen (188 psia). These studies were prompted by requirements for rapid chilling and startup of liquid hydrogen pumping systems. The results may be useful in the design of pumps and other low-temperature flow devices. The work may be extended easily to cover other gases.

The properties of five metals with varying tube-wall thickness, with or without an internal coating of trifluorochloroethylene polymer, were studied. Results showed that wall characteristics influence flow stability, markedly affect heat transfer coefficients in the dry-wall (film boiling) portion of the cooldown, and also influence somewhat the transition point from dry- to wet-wall flow. The insulating coating stabilized the flow during cooldown, reduced vapor formation rate under rapid flow conditions, and accelerated cooldown rate during low-velocity flow. Equations have been derived for determining the optimum coating thickness.

Theoretical steady-state heat-transfer functions proposed in the literature for two-phase hydrogen flow were compared with experimental heat-transfer data obtained in the dry-wall portion of the cooldown. Reasonable agreement was obtained at the initiation of cooldown (high wall temperatures). Agreement in the low wall-temperature region was not as good, possibly because of the effect of tube-wall parameters on flow near the wall, or as the result of a delay in recondensation of the vapor formed near the wall. These two factors have not been included in steady-state heat-transfer theory.

The investigation of instability was performed using an electrically heated, tubular test section, through which two-phase hydrogen was passed. Flow stability regions and heat-transfer characteristics were determined simultaneously at pressures varying from near-critical to critical. Unstable flow occurred even when the fluid remained subcooled through the entire test section. Under such conditions, the flow-rate required to suppress instability was relatively high, while with bulk boiling present, a much lower flowrate could be tolerated. Three modes of oscillation were identified in the unstable flow; all exhibited high damping characteristics.

Notes:

1. For information on a similar investigation of two-phase nitrogen flow, refer to Tech Brief B69-10541, Cryogenic Fluid Flow Instabilities in Heat Exchangers.
2. Requests for further information may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama 35812
   Reference: TSP70-10259

Patent status:

No patent action is contemplated by NASA.

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